GROUNDWATER RECOVERY WELL WORK PLAN

BAYER POLYMERS
NEW MARTINSVILLE, WV FACILITY

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1.0 INTRODUCTION

This document presents the Work Plan for the groundwater portion of the remedial alternative for Solid Waste Management Unit (SWMU) Group A at the Bayer Corporation (Bayer), New Martinsville, West Virginia facility.

1.1 FACILITY OVERVIEW

The Bayer, New Martinsville Plant is situated within the Ohio River Valley at the base of the West Virginia Northern Panhandle in both Marshall and Wetzel Counties (Figure 1-1). The facility was constructed in 1954 and produced polyester resin. In 1956, the Bayer (then Mobay) New Martinsville facility became the first in the United States to produce toluene diisocyanate (TDI), which is polyisocyanate or polyurethane resin used to make polyurethane foams. In 1962, a polymeric isocyanate unit was started, and in 1977, construction began on the iron oxide pigment production facility. The iron oxide pigment production facility was put into operation in 1980 and ceased operation in 1998. Throughout its history, several other products, most of which are used in the polyurethane production process, were produced at the facility.

Polycarbonate was also produced at this plant from 1957 to 1982. Polycarbonate is a synthetic thermoplastic resin and was produced using bisphenol-A, methylene chloride, and phosgene. Polycarbonate is used for the production of molded products such as piping, tubes and structural parts, prosthetic devices, unbreakable windows and household appliances. Production of polycarbonate at Bayer, New Martinsville facility ceased in 1982. Today the plants primary products include polyurethane resins such as TDI, methylene diphenyl diisocyanate (MDI), polyols, polyethers, and polyesters. Hydrochloric acid is a by-product of isocyanate production, which is sold to other manufacturers.

1.2 REGULATORY STATUS OVERVIEW

Bayer completed a RCRA Facility Investigation (RFI) for 30 Solid Waste Management Units (SWMUs) at its New Martinsville, West Virginia facility. The final RFI report (IT Corporation, January 31, 2000) was submitted to the United States Environmental Protection Agency (USEPA) and West Virginia Division of Environmental Protection (WVDEP).

Based on the results of the RFI and ensuing discussions with the USEPA, Bayer decided it would be prudent to evaluate a focused set of remedial alternatives to protect groundwater and the bordering Beaver Run backwater from the constituents detected at potential levels of concern in SWMU Group A. SWMU Group A is comprised of four SWMUs at the south end of the New Martinsville facility (SWMU 1: South Landfill, SWMU 2: Sludge Lagoon, SWMU 3: Fill Area Hydroblasting Station, and SWMU 4: Ash Lagoon). SWMU Group A occupies an area of approximately five acres and borders the Beaver Run backwater (Figure 1-2). The RFI determined that SWMU Group A does not present direct contact human health risk, but is a potential source of contaminant leaching to groundwater. There is also concern that contaminants may migrate from the landfill to the Beaver Run Backwater.

The presumptive remedy, which has been accepted by the USEPA (in concept), will eliminate the need for carrying SWMU Group A through the formal Corrective Measures Study (CMS) process. Several alternatives and technologies were evaluated. Based on effectiveness, implementability, agency acceptance, and cost. The presumptive remedy includes removing waste from the Ash Lagoon, and placing it near the Hydroblasting Station, thereby consolidating the four SWMU's into the smallest footprint. The entire landfill area would be re-graded to specifications and an engineered cover would be installed. At the same time, Beaver Run Backwater would be filled in and Beaver Run re-routed to Dry Run, located to the south. All impacted wetlands would be relocated to the Dry Run stream course and backwater. In addition, a groundwater recovery well will be installed within the landfill footprint, with piping to convey the groundwater to the on-site treatment system prior to discharge to augment the existing groundwater recovery system.

1.3 SWMU GROUP A CONCEPTUAL MODEL

SWMU Group A is located in the south end of the plant and is comprised of four original SWMUs (original SWMU number are, SWMU 1: South Landfill; SWMU 2: Sludge Lagoon; SWMU 3: Hydroblasting Station; and SWMU 4: Ash Lagoon). SWMUs 1, 2, and 3 manifest as a single, topographic high, cover approximately four acres of surface area immediately south of the Bayer, New Martinsville Environmental Control Division (ECD), and borders the north bank of the Beaver Run Backwater (Figure 1-2). SWMU 4 covers an additional acre in a depression immediately northeast of the landfill.

1.3.1 SWMU 1: South Landfill

The South Landfill began accepting fill in 1955 and a soil layer was placed over the fill in 1992-1993. Disposal records prior to 1986 are not available. Materials known to be disposed at this site include construction debris, plant residues, polyurethane strands and chunks, solids, shipping crates, packing materials, refractories, crushed metal, asbestos insulation, polyol and polyether type material, scrap metal and miscellaneous 55 gallon drums. Bayer believes that process related residues (with the exception of iron oxide process residue) were not placed within the south landfill after 1980. Placement of iron oxide residue within the South Landfill was discontinued in 1989.

Topographic maps of this area dated February, 1966 indicate the ground surface elevation of the area was approximately 630 to 635 ft-MSL. The normal pool elevation of the Ohio River at that time averaged 601 ft-MSL. In the early 1970's, when the former sludge lagoon (SWMU 2) was constructed to contain clarifier sludges, portions of the property south and east (SWMU 1) were proposed to be used as a borrow area. In anticipation of the construction of the Hannibal Lock and Dam (and a subsequent rise in river and backwater elevations), a series of dikes were constructed and the course of Beaver Run was altered. By April, 1972, the area of the current south landfill had been excavated to an elevation between 611 and 615 ft-MSL. Completion of the Hannibal Lock and Dam in 1973 increased the Ohio River pool elevation to about 620 ft-MSL and created backwater areas around the south landfill outside of the dikes. Water level data collected from monitoring wells LF-1 through LF-7 (installed in 1984) located within the south landfill indicate that groundwater within the alluvial aquifer rose to an elevation of approximately 619 ft-MSL in response to the increased river pool level. Placed within the landfill were construction debris, plant residue and miscellaneous plant operating wastes outlined above. Landfilling of process related residues (except for non-hazardous iron oxide process residue) was discontinued by 1980. Placement of iron oxide residue within the south landfill and sludge lagoon area raised the maximum ground surface elevation to approximately 645 ft-MSL in 1988, with iron oxide placement being discontinued in 1989.

The RFI determined that the depth of waste from the top of the landfill to the bottom ranges between 21 and 51 feet, which corresponds to a bottom elevation for the waste material of approximately 608 ft-MSL. This elevation is about 7 feet higher than the original level of the Ohio river prior to the construction of the Hannibal Lock and Dam complex but is approximately 12 to 16 feet lower than the current normal pool elevation.

Based on RFI test boring logs, waste materials encountered in the upper 5 to 12 feet of the landfill consist primarily of iron oxide pigment residues, construction debris, rubble, and small amounts of miscellaneous waste mixed with silt, clay and gravel. In general, perched groundwater zones were encountered only within the basal portion of the upper fill deposits.

Wastes encountered within the lower fill (below approximately 12 feet) included waste plastics (e.g., solidified resins), construction/demolition debris, waste metal and wire, waste iron oxide pigment, sludges, and process-related residues (e.g., TDI residue). Landfilled waste is mixed with gravel, clay and silt, which comprises from 20 to over 50 percent of the materials encountered during drilling. Process-related wastes do not generally occur as discrete units within the lower landfill deposits. Rather, these wastes normally comprise only a portion of the heterogeneous matrix of debris, soil, and other materials encountered throughout the lower fill. Due to this heterogeneity, the ability to positively identify specific process-related wastes within the samples collected during RFI drilling was limited.

Naturally occurring subsurface materials immediately below fill deposits (at an elevation of 608 ft MSL) are composed primarily of silty to clayey fine sand. The silty sand unit is not continuous beneath the South Landfill area. Where absent, the silty sand unit is replaced by silty clay or silt and clay. The silty sand and/or silt and clay deposits are underlain by the fine to coarse sand and fine gravel outwash deposits, which comprise the main body of the alluvial aquifer. Beneath the south landfill/former sludge lagoon area, these main aquifer deposits range from 24 to 31 feet in thickness and extend to bedrock at a depth of approximately 75 ft-bgs.

1.3.2 <u>SWMU 2: Sludge Lagoon</u>

Located north of the landfill in the southern portion of the plant, the two-acre, 30 feet deep Sludge Lagoon was originally constructed to dispose of clarifier sludge. Beginning in 1971, wastewater treatment (clarifier) sludge was disposed of in the lagoon, which accepted the sludge through 1975. Sludge was intermittently placed in the sludge lagoon from 1975 through 1979. After 1979, bulk fill material was placed directly over the sludges. This fill material was composed of the same material sent to the South Landfill. Within the sludge lagoon, 18 feet of process-related residues (primarily iron oxide residue) mixed with soil have been placed as cover upon 25 feet of clay-like clarifier sludges and various plant residues. The bottom of the waste is at an elevation of approximately 603 ft MSL.

The following materials are estimated to remain in place at this unit: iron oxide kiln residue (12,000 tons); clarifier sludge (17,000 tons); isocyanate residues (3,000 tons); filtercakes (2,500 tons); toluene diamine residue (200 tons); fill dirt (11,000 tons); and drummed isocyanates and resins (2,000 tons). Known wastes disposed of within the lagoon include TDI residue and clarifier sludge. With the exception of iron oxide residue, landfilling of process related residues was discontinued by 1980.

1.3.3 SWMU 3: Hydroblasting Station

The Hydroblasting Station is a 24 feet by 36 feet concrete pad, which slopes to a sump located below grade. The sump was used to hold water and waste from truck washing operations. The area was used to clean equipment; removing solids, which had accumulated during operation and movement of waste during the 1980's. The hydroblasting station was constructed within the boundaries of SWMU 1 (South Landfill), which is composed of debris, process-related wastes and residues, and clayey or gravelly soils as outlined above.

1.3.4 SWMU 4: Ash Lagoon

The Ash Lagoon was formed in 1973 by excavating and diking the area. The Ash Lagoon is an unlined, irregularly shaped impoundment covering approximately one acre, which is located over the former streambed of Beaver Run, northeast of the South Landfill and east of the Sludge Lagoon.

The depth of the waste in the impoundment ranges from approximately 12 feet in the northern portion of the lagoon to approximately 6 feet in the southern portion. The total volume of the waste in the impoundment is estimated to be approximately 14,000 yd^3. Ash slurry from the incineration of clarifier sludge in the multiple hearth sludge furnace was discharged to the lagoon with excess water transported back to the wastewater treatment area. The lagoon is covered by impounded rainwater as well as grasses and brush. A small dike structure separates the Ash Lagoon from the Beaver Run Backwater. No ash was deposited in the lagoon after 1980.

1.3.5 Groundwater Influences on SWMU Group A

Groundwater occurs in SWMU Group A under both perched and water table conditions. The following sections will expand on each of these conditions.

1.3.5.1 Perched Groundwater

RFI data show perched groundwater occurs in SWMU Group A within SWMUs 2 and 4. The perched water in SWMU 2 is found at approximately 15 ft-bgs (635 ft-msl) and in SWMU No. 4 at 5 ft-bgs (631 ft-msl). Perched groundwater zones form within relatively higher permeability materials that are underlain by relatively lower permeability materials, which restricts infiltration of precipitation. Migration of groundwater in perched zones is primarily lateral, resulting in the possible horizontal migration of contaminants beyond the SWMU Group boundary. Some perched zones may manifest as seeps following precipitation events. Vertical migration of perched groundwater also promotes the leaching of wastes downward to the water table.

1.3.5.2 Water Table

Bayer operates three groundwater recovery wells to hydraulically capture site-wide groundwater (Figure 1-3). Under typical operation of these wells, the vast majority of the landfill waste is situated above the water table. RFI data for SWMU Group A shows that 1 to as much as 14 feet of waste material is below the water table in some areas while these wells are operating. If these recovery wells were shut down, the water table would rebound to non-pumping static conditions, resulting in additional waste beneath the water table. This rebound, or rise in the water table, would be to an estimated level slightly above the former Beaver Run Backwater and Ohio River (about 624 ft-msl). According to the steady state groundwater model, the groundwater from around SWMU Group A would not show any outward migration for at least 48 to 72 hours following the shut down of recovery well pumps. If all recovery well pumps were turned off, all groundwater migration is towards the north. Under non-pumping static conditions, approximately 18 feet of waste material would be present beneath the water table at SWMU Group A. However, under future pumping conditions (with the addition of a groundwater recovery well) the groundwater elevation will be reduced, and the waste material within SWMU Group A will be pumped so that the leaching of the waste constituents will be reduced.

1.3.6 Surface Water Influences on SWMU Group A

Surface water is believed to significantly influence SWMU Group A leaching to the underlying groundwater. SWMU Group A was bounded on the south and east sides by the Beaver Run Backwater, which came in direct contact with the South Landfill and the Ash Lagoon and represented a constant source of recharge to the aquifer under current pumping conditions. The Beaver Run Backwater has recently been backfilled as part of the first Phase of the remedial action. A Phase 1 report will be submitted to the WVDEP and USEPA in February 2004. The west side of the South Landfill and the Sludge Lagoon are separated from the Ohio River by a narrow strip of land occupied by a railroad grade, so the recharge is somewhat impeded. The elevation of the Beaver Run Backwater was a direct result of the Ohio River stage, which is controlled by the Hannibal Lock and Dam located approximately 5 miles down river. The Ohio River and Beaver Run Backwater were connected by a small culvert that runs under the railroad grade. This culvert has recently been sealed as part of the Phase 1 remedial action completed in December 2003.

During Phase 3 of the RFI, a series of confirmatory soil borings were advanced around the perimeter of the entire South Landfill Complex at 40 ft intervals to determine the lateral limits of the waste. Hand augers advanced by the waters edge on the south side of the South Landfill, indicated that waste was present near or had the potential for direct contact with the Beaver Run Backwater. Under pumping conditions, induced river and backwater inflow becomes the main source of aquifer recharge. Current groundwater elevation data indicates that hydraulic gradients are sloping into the alluvial aquifer (i.e., induced recharge) from the major surface water bodies, so the water may pass through a portion of the waste in the South Landfill before reaching the alluvial aquifer.

1.3.7 Surface Water, Sediment and Groundwater Quality

Analytical samples were collected for surface water, sediment, and groundwater quality as part of the Phase 2 RFI. The results of these analyses were submitted to the USEPA Region III as part of the Phase 2 RFI Technical Memorandum, April 30, 1998.

1.3.7.1 Surface Water

Nine surface water samples were collected from the Beaver Run Creek and Beaver Run Backwater, as part of the Phase 2 RFI Investigation, and were analyzed for VOC, SVOC, TSS, TDS, nitrate, COD, pH, oil and grease, TOC, BOD, TKN, and metals. Additional surface water samples were collected from meteoric waters trapped in the Ash Lagoon.

The analytical results for the surface water in the Beaver Run Creek and Backwater indicate that bis(2-ethylhexyl)phthalate (a common laboratory contaminant) exceeded the risk-based concentrations (RBCs) for tap water. The screening criteria is based on drinking water exposure and is very conservative, especially considering a surface water that will not be used for drinking water. A comparison of the surface water data for Beaver Run Backwater to freshwater screening values based on the protection of aquatic organisms indicates that no constituents exceeded these criteria.

The analytical results for the Ash Lagoon indicate that benzene and m,p-cresol exceed their tap water RBCs. However, a comparison of the surface water data for the Ash Lagoon to freshwater screening values based on the protection of aquatic organisms indicates that no constituents exceeded these criteria. In general, the water quality will support aquatic organisms, but will not pass the rigid standards of tap water.

1.3.7.2 Sediments

Sediment samples were collected at the same locations as the surface water samples along Beaver Run Creek and Backwater. Sediment samples were also collected within the Ash Lagoon.

The RFI analytical results for the sediment samples in the Beaver Run Creek and Backwater indicate that no constituents were detected at concentrations exceeding either the industrial or residential RBCs. However, the concentration of four metals (cadmium, chromium, lead and nickel), one VOC (chlorobenzene) and two SVOCs (1,2-dichlorobenzene and di-n-butyl phthalate) exceeded the ecological sediment screening values. This occurred in only a few samples.

As expected, the analytical results for the sediment samples from the Ash Lagoon indicate higher concentrations of the same constituents and detections of others. Lead and benzene concentrations exceed the industrial and residential RBCs, while chromium and nickel exceed the residential RBCs. Four metals, four VOCs, and four SVOCs exceed ecological screening criteria.

1.3.7.3 Groundwater

According to the Annual Groundwater Monitoring Information Report for 2002, monitoring wells from the area in and around SWMU Group A indicate that one monitoring well had an elevated concentration of nickel. Several monitoring wells had elevated concentrations of SVOCs, with the highest concentrations being aniline, 2,4-toluenediamine, p-chloroaniline, and 1,2-dichlorobenzene. Elevated concentrations of the VOCs 1,2-dichlorobenzene, chlorobenzene, and benzene were also detected in groundwater samples from SWMU Group A.

1.4. EXISTING RECOVERY WELLS

As previously mentioned, Bayer operates three groundwater recovery wells to hydraulically capture site-wide groundwater. These recovery wells are designated RW-1, RW-2A, and RW-3A, and are roughly placed in a North to South line within the central spin of the plant (Figure 1-3). Recovery wells RW-1, RW-2, and RW-3 were drilled and constructed in December 1985 by Geraghty & Miller, Inc. Sample descriptions and logs are provided in Appendix A. Recovery Wells RW-2 and RW-3 were replaced in June and July 1997, by ICF Kaiser Engineers, and were renamed RW-2A and RW-3A respectively.

The existing recovery wells collectively pump approximately 300 gallons per minute (gpm) to maintain hydraulic capture of the groundwater on site. The pumping rates and hydraulic capture are maintained and documented in both the quarterly and annual groundwater reports submitted to USEPA and WVDEP by March 1 of each year, with data from the previous year.

All groundwater is pumped to the on-site treatment facility where it is treated prior to discharge via a permitted NPDS outfall. The groundwater is pumped through 4-inch discharge lines from the recovery wells to a 6-inch overhead conveyance line. The conveyance line is part of an overhead pipe rack system that spans the entire north-south length of the plant.

2.0 RECOVERY WELL DESIGN

The recovery well design must consider the purpose of the recovery well, the placement or location of the recovery well, the required production of groundwater, depth, sediment size (for determining the screen slot size and length), and pump requirements. These considerations are outlined in the following sections.

2.1 PURPOSE

The primary purpose of the recovery well is to contain any constituents of concern within SWMU Group A. This will be accomplished by lowering the elevation of the groundwater level, and by pulling groundwater towards the central portion of the South Landfill. The recovery well will augment the extraction effort of the existing recovery wells as insurance against migration of constituents of concern off-site. The recovery well will also be included in the site-wide groundwater monitoring program to monitor constituent concentrations.

2.2 DESIGN CRITERIA

The design requirements for the SWMU Group A recovery well (RW-4) include the ability to produce 300 gallons per minute (gpm), maintain the hydraulic capture of the affected groundwater at the facility, and reduce the impact to the groundwater. The recovery well design considers two components. The initial part consists of the well casing and the well screen, which are used to collect and store the groundwater, while impeding the movement of formation materials into the well. The second portion of the design considers the conveyance of the water to the surface to be treated. This part of the system includes the pump and the discharge line.

2.3 WELL LOCATION

The groundwater containment system will consist of a recovery well to be situated within SWMU Group A, in the southern portion of former SWMU 2: Sludge Lagoon (Figure 2-1). This site has been chosen to satisfy a number of requirements. Due to the absence of specific hydrogeological information in the vicinity of the South Landfill, which is required to support the design of a recovery well, Bayer has developed and executed a site-wide groundwater model to determine the number of wells needed, the best location for the recovery well, depth of penetration, and pumping rate. The steady state groundwater model was used to evaluate five locations within the central portion of the landfill in an effort to determine if one site was better than another for the recovery well. The model runs, which are outlined in an accompanying document (Groundwater Flow System and Steady State Flow Modeling, January 2004, under separate cover), determined that the sediments beneath the landfill performed equally well in the proposed pumping scenario. Geographically, the chosen site will be close to the center of the finished South Landfill, once final grading is complete. A central location is desirable to help maintain the uniform draw-down of groundwater within the footprint of the landfill. Information derived from the steady state groundwater model on site, determined that this location will maintain capture of any constituents that may be present in groundwater beneath the South Landfill (Figure 2-1).

Following the installation and development of the recovery well, pumping tests will be performed to evaluate to performance of the recovery well and the precision of the model. The steady state groundwater model was run with RW-4 in the proposed location, pumping at 150 gpm. Draw-down within the sentry monitoring wells is estimated to be between 1 and 1.5 feet. Details of the steady state groundwater model can be found the accompanying document Groundwater Flow System and Steady State Flow Modeling, January 2004 under separate cover.

Monitoring Well	Total Depth (feet)	Elevaltion Ground (ft-MSL)(2)	Elevaltion (1)TOC$_{PVC}$ (ft-MSL)(2)	Screened Interval From (ft-bgs)(3)	Screened Interval To (ft-bgs)(3)	Screen Length (feet)	Transducer Installation	Expected Drawdown (feet)
LF-1D	64	636.12	637.54	39	64	25	X	**1.2**
LF-2D	64	634.89	636.62	39	64	25	X	**1.5**
LF-3D	68	637.73	639.65	43	68	25	X	**1.4**
LF-4D	60	633.64	635.51	35	60	25	X	**1.3**
LF-5D	59	632.52	634.1	34	59	25	X	**1.3**
LF-6D	58	630.74	632.61	33	58	25	X	**1.3**
LF-7D	60	631.45	632.89	35	60	25	X	**1.2**
OTW-4	N/A(4)	633.26	635.46	N/A	N/A	N/A	X	**1.3**

Notes (1) TOC$_{PVC}$=Top of Casing (PVC)
(2) ft-MSL=feet above mean sea level
(3) ft-bgs=feet below ground surface
(4) N/S=Not Available

Lastly, the waste contained within the Sludge Lagoon SWMU consist of iron oxide process residue, clarifier sludge, waste water treatment sludge, and lesser amounts of bulk fill material similar to what was placed in the South Landfill SWMU. This material is thought to be penetrated easier than in areas to the south, increasing the chances of a successful completion, regardless of the rig type chosen for the job.

2.4 WELL DESIGN

The recovery well design considers two components. The initial part consists of the well casing and the well screen, which are used to collect and store the groundwater, while impeding the movement of formation materials into the well. The second portion of the design considers the conveyance of the water to the surface to be treated. This part of the system includes the pump and the discharge line. Both components are designed around the expected pumping or production rate. The pumping rate for this recovery well is expected to mimic the pumping rates of the existing recovery wells, at 150 gallons per minute (gpm). However, the recovery well will be designed to accommodate a higher rate (as high as 300 gpm) as insurance for future needs.

According to table below (after Driscoll, 1987), a 10-inch inside diameter (ID) screen and casing are recommended for a well to produce 300 gpm, however, RW-4 will operate at 150 gpm. This ID is needed to accommodate the size and tooling needs of a pump rated to 300 gpm as outline in the following sections.

Recommended Well Casing Diameters
For Various Pumping Rates

Anticipated Well Yield GPM[1]	Nominal Size of Pump Bowls (inches)	Optimal Size of Well Casing (inches)	Smallest Size of Well Casing (inches)
< 100	4	6 ID[2]	5 ID
75 to 175	5	8 ID	6 ID
150 to 350	6	10 ID	8 ID
300 to 700	8	12 ID	10 ID

Notes (1) Gallons per minute
(2) Inside Diameter
After Driscoll, 1987

2.4.1 Screen Slot Size

The design of the well screen takes several factors into account. As mentioned above, the ID of the well screen is dictated by the pump size, but the slot size (open area of the screen) and the length of the screen must be calculated. Field experience and laboratory tests show that the average entrance velocity of water moving through a screen should not exceed 0.1 ft/sec. At this velocity the friction losses in the screen openings will be negligible, and the rates of incrustation and corrosion will be minimal. Velocities less than 0.1 ft/sec will increase the life of the well and decrease the chances of dislodging formation fines (sand pumping), which will enter the well and pump. The screen slot size must also impede the formation sediments from entering the well. Lengthening the screen (which increases the surface area), while maintaining the slot size, will reduce the entrance velocity.

Currently, there are no formation samples from the proposed well location, so a grain size distribution chart cannot be generated. Without a grain size distribution chart, the screen slot size cannot be accurately determined at this time. The sediment samples will be obtained by advancing a pilot hole at the proposed location. Split spoons will be collected every two feet after reaching the base of the landfill, in order to collect sediment samples to be used in a grain size analysis, which produces a grain size distribution chart (Section 3.1.1). The results of the grain size analysis will determine the slot size for the screen (Section 3.1.2). However, using information from the existing recovery wells, an average slot size of 0.03-inch is estimated.

2.4.2 <u>Screen Length</u>

As previously determined, 10-inch ID casing will be required to accommodate the pump and discharge line. At this time the screen slot size cannot be determined, but is estimated to be a 0.03 inch slot. However, the determination of the screen length, which relates directly to the surface area of the screen opening can be explained. In unconsolidated sediments, it is assumed that 50 percent of the screen slots will be blocked by the sand grains, so the well screen must be designed to produce at least twice as much water as required. The average entrance velocity is calculated by dividing the required well yield by the total area of the screen openings. If the velocity is greater than 0.1 ft/sec, the screen length and/or diameter must be increased to allow enough open area so the entrance velocity is 0.1 or less. Screen slot sizes are usually accompanied by the representative open areas in square inches (in^2). Using the equation Q=VA, where Q is discharge, V is the flow velocity, and A is the cross sectional area:

$$Q=VA$$

$$\text{Where} \quad Q = ft^3 = \frac{(gal/min)/(7.48\ gal/ft^3/sec)}{60\ sec/min}$$

$$A = ft^2 = \frac{X\ in^2}{144\ in^2/ft^2}$$

$$V = ft/sec$$

Setting the velocity (V) to equal 0.1 ft/sec, gallons per minute can be calculated for every foot of screen, by deriving a conversion factor as outlined below:

$$\mathbf{Q = V \times A}$$

$$\frac{(gal/\min)\big/(7.48 gal/ft^3/\sec)}{60\sec/\min} = (0.1 ft/\sec)\left(\frac{Xin^2/ft}{144 in^2/ft^2}\right)$$

$$\frac{gal/\min}{7.48 gal/ft^3/\sec} = (0.1 ft/\sec)\left(\frac{Xin^2/ft}{144 in^2/ft^2}\right)(60\sec/\min)$$

$$\frac{gal/\min}{7.48 gal/ft^3/\sec} = Xin^2/ft\left[\frac{(0.1 ft/\sec)(60\sec/\min)}{144 in^2/ft^2}\right]$$

$$gal/\min = Xin^2/ft\left[\frac{(0.1 ft/\sec)(60\sec/\min)}{144 in^2/ft^2}\right][7.48 gal/ft^3/\sec]$$

$$gal/min = (Xin^2/ft)(0.3117)$$

Table 2-1 lists the standard open areas and specific manufacturers open areas for various slot sizes in 10-inch ID stainless steel screen with the resulting gallons per minute at 0.1 ft/sec. Table 2-1 also shows the calculated gallons per minute for a section screen twenty feet long, and for the same section of screen that is 50 percent blocked by sand grains. This table can be used as a guideline for screen selection after the grain size distribution is known.

It is anticipated that the recovery well will require a 20-foot section of 0.03-slot (average), continuous wrap 304 stainless steel screen (Table 2-1). However, it is expected that the sediments present within the aquifer will have a bimodal distribution of grain sizes, given the fluvial/glacio-fluvial depositional regime in which they were deposited. The sediments are not homogeneous, but occur in layers. Non-homogeneous formations usually occur because the magnitude of the forces responsible for the erosion and deposition of the sediments tend to vary over relatively short periods of time (droughts, floods, etc.). When designing screens for these formations, slot openings for different sections of the well may be chosen according to the gradation of the materials in the different layers. The screen may have a 0.01-inch slot for the upper 7 feet, followed by a larger slot. When fine material overlies coarse material (as expected), at least three feet of the screen designed for the fine material must extend into the coarse material below. The slot size should not be doubled under a distance of two feet. For example; if 0.01-inch slot is required for the upper section and 0.03-inch slot is required for the lower section, a 2-foot transition piece of 0.02-inch slot should be placed between the differing zones.

2.4.3 Discharge Line

Working backwards from the design capacity of 300 gpm (the actual pumping rate is estimated at 150 gpm), the discharge line, which is attached to the pump and runs up through the casing, needs to be sized. According to published data (Driscoll, 1987), various pumping rates require specific diameter discharge lines. In an effort to avoid excessive head losses, which occur if the up-hole velocity is greater than 5 feet per second (ft/sec), a discharge pipe with a 6-inch diameter discharge line will be required. This figure is based on published tables, but can also be calculated by using the formula for a cylinder (r^2h), with a height (h) equal to 5 feet, to yield to cubic feet of water in a section of pipe 5 feet long. Multiplying the resulting area (ft^3) by the conversion factor, 7.48 gal/ft^3, yields the amount of water passing through the pipe in one second. The gallons per minute are simply calculated by multiplying by 60 seconds per minute as indicated below.

$$\left[\Pi\left({}^{3inches}\!\big/_{12inches/foot}\right)^2(5ft)\right]\left[7.48ga/ft^3/\sec\right]\left[60\sec onds/\min\right]=440gal/\min$$

2.4.4 Pump

Either a vertical turbine or submersible pump can be used to convey the groundwater to the surface and then to the treatment facility. A vertical turbine is powered by a motor at the surface, with a shaft and impellers within the well. Each set of impellers is housed in a bowl assembly, and a sufficient number of stages (bowl assemblies) are stacked to meet the head requirements of the system. Ideally, the pump intake with this type of system should not be positioned within the well screen, so it is recommended that a submersible pump be used in the Bayer, New Martinsville recovery well.

Submersible pumps generally have an impeller assembly with an intake screen sitting above the motor. The entire pump is lowered into the screened portion of the well. As the water enters the intake, it passes through the impellers, then up through the pump column (discharge line) to the surface. The pump is cooled by water passing by the motor casing and into the intake of the pump, so a free flow of water must be maintained. A submersible pump with approximately 20 horsepower, requiring three phase wiring will be required. It is anticipated the conveyance pipe used to route the groundwater to the on-site treatment facility, and the electrical hook-up, will be in place prior to drilling the recovery well.

2.4.5 Well Maintenance

The recovery well will require maintenance of either the pump or the well over time. To determine any loss in performance, some reference mark is needed. Performance standards are established by conducting a pumping test as part of the completion of the recovery well. The data from this test will allow Bayer, New Martinsville personnel to detect any drop in yield.

The reasons for maintenance include pump repair or replacement. Pumps wear out over time and need replaced. This is easier on a vertical turbine pump, because the motor is on the surface. A submersible pump must remove the entire discharge line to work on or replace the pump motor.

Well problems in this type of aquifer are most frequently silt and sand intrusion. Some wells always pump sand, while other wells may begin to pump sand after months or years of service. Factors that contribute to sand pumping are corrosion, and fluctuating pumping rates. The recovery well will be equipped with a sump located below the screen to catch silt and sand so that it can be removed periodically. Other well problems in this type of aquifer include iron precipitation, screen incrustation, and biologic fouling.

Due to their importance and cost, it is Bayer's practice to maintain wells periodically. The maintenance requires that the pump be shut down for a short period of time. It has been, and will continue to be Bayer's practice to increase the pumping rates on the remaining recovery wells to maintain the hydraulic capture at the site. The annual groundwater reports provide evidence of hydraulic capture without RW-4. This recovery well will augment the plant-wide system, while providing a localized depression in the groundwater elevation.

3.0 RECOVERY WELL INSTALLATION

The installation of the recovery well (RW-4) will occur in two stages. Initially, a pilot hole will be advanced as an exploratory boring, gathering information pertinent to completing the design of RW-4, as well as aiding in the rig selection/drilling procedure for the well installation. The second portion of the installation is the mobilization of a second drilling rig to install the larger casing and screen, as well as develop the recovery well.

In order to minimize risks, the breathing space will be monitored using PID equipped with a 10.2 eV lamp. All cuttings and soil samples will be containerized at the boring location. Drums will be provided by Bayer, New Martinsville for the containerization of drill cuttings. Bayer, New Martinsville personnel will also transport the drums to a central location (Environmental Control Division) using union labor on site.

The drilling rig, associated down-hole tools, and support vehicles will be decontaminated during the drilling program to prevent the possibility of cross-contamination between locations. A decontamination station will be established on-site for cleaning the heavy equipment with a high-pressure hot-water power washer. The decontamination soils and liquids will be collected and placed in 55-gallon steel drums for storage and eventual disposal.

Small hand tools and split-barrel samplers will be manually washed using the following procedure:

Potable water and soapy water wash using non-phosphatic detergent.
Rinse with potable water.
Air dry.

3.1 INITIAL DRILLING

Following the selection of the recovery well location, a hollow stem auger (HSA) rig will be employed to advance a pilot hole to investigate the exact depth to the bottom of the waste. Information from soil borings logs advanced during Phase 2 of the RFI, was used to determine the approximate depth of the bottom of the waste. Using boring logs SM001-TB06, SM002-TB01, and SM002-TB02 (Appendix B), it has been determined that the base of the waste should have an elevation of approximately 603 ft-

MSL. The location identified for RW-4 has a current elevation of approximately 652 ft-MSL, so it is expected that the base of the waste will be approximately 49 ft-bgs.

The HSA rig will drill to approximately 48 ft-bgs before collecting 24-inch split spoon samples in accordance with ASTM standard D 1586. The split spoon samples will be collected every two feet until directed by the supervising geologist. The soil samples within the split spoon will be field-classified according to the Unified Soil Classification System (USCS) and screened with a PID using a 10.2 eV lamp. A representative sample from each split spoon will be collected for use in a sieve analysis.

3.1.1 Sieve Analysis

The sieve analysis will be conducted on dried sediment samples. The sieve analysis is conducted by selecting five to eight sieves with a series of openings that will separate the sample into various grain sizes. The coarsest sieve should not retain more than 20% of the sample. The sieves are stacked so that the coarsest is on top and the finest is on the bottom, with a bottom pan. A weighed sample (normally 200 to 300 grams) is poured into the top screen, and the entire set of screens is shaken and rotated for at least five minutes.

The contents of each screen, including particles that need to be dislodged, are then weighed and recorded for each screen size. The accumulated weight should be equal to the weight of the original sample within three to five grams. The cumulative percent weight retained on each test sieve is plotted as a point in thousandths of an inch or mm. Percent retained is usually placed on the vertical scale and the size opening (particle size) is placed on the horizontal scale. A distribution curve is then generated, and a uniformity coefficient for the grain size distribution is derived. A relative hydraulic conductivity can also be estimated from the grain size distribution as indicated in (Figure 3-1).

3.1.2 Screen Slot Size Selection

The primary use of the grain size distribution is in determining the slot size for the screen (Figure 3-1). It is expected that the sediment present within the aquifer will have a bimodal distribution of grain sizes, given the fluvial/glacio-fluvial depositional model along the Ohio River. Screen slot openings for the same formation can differ depending on whether the well is naturally developed or filter packed.

Coarse-grained non-homogeneous (bimodal distribution) material, which is expected at the RW-4 location, can be naturally developed, whereas fine-grained homogeneous materials are best developed using a filter pack. In a naturally developed well, the screen slot size is selected so that most of the finer formation materials near the borehole are brought into the screen and pumped from the well during development. This results in creating a zone of graded formation materials extending one to two feet outward from the screen. To determine the correct slot openings for non-homogeneous sediments, the typical approach is to select a slot through which 50 to 60 percent of the material will pass and 40 to 50 percent will be retained.

As previously mentioned, non-homogenoeous formations usually occur because the magnitude of the forces responsible for the erosion and deposition of the sediments tend to vary over relatively short periods of time. When designing screens for these formations, slot openings for different sections of the well may be chosen according to the gradation of the materials in the different layers. When fine material overlies coarse material (as expected), at least three feet of the screen designed for the fine material must extend into the coarse material below. The slot size should not be doubled under a distance of two feet.

After the screen specifications have been determined, the well screen will be ordered. It is anticipated that the average slot size will be approximately 0.03-inch slot. The well screen will be 10-inches in diameter, and the length of the screen (to gain surface area of slots), is anticipated to be 20 feet. Screen materials are expected to be 304 stainless steel with high carbon steel casing used for the sump and riser.

3.2 SECOND DRILLING

The second portion of the well installation consists of mobilizing a larger rig, which is capable of installing the 10-inch ID screen and associated riser. If the information obtained during the advancement of the pilot hole suggests that the number and nature of obstructions is not conducive to using an HSA rig, an alternative method such as Odex or Rotosonic may be used. These drilling methods advance the casing as the boring is advanced. Odex is an air-rotary method uses an eccentric (off-centered) bit located above a down-hole hammer. This arrangement cuts a borehole slightly larger than the casing, allowing the casing to drop into place under it's own weight. It may be necessary to drive the casing occasionally, if it does not fall into place. A Rotosonic rig vibrates the casing into place as the boring is advanced.

Assuming the HSA rig can be used, 12 ¼ -inch hollow stem augers with an outside diameter of approximately 18 inches will be needed. This diameter is the smallest diameter that will accept the 10 ¾ -inch outside diameter (OD) casing in the recovery well design. The high carbon steel casing, which is used as both the sump and the riser, has an ID of 10 inches to match the well screen, and a 3/8-inch wall. The specified screen is expected to have an OD of 10 7/8 inches.

It is expected that the boring will be advanced through the waste material to the top of the naturally occurring material at approximately 50 ft-bgs as indicated by RFI Phase 2 soil borings SM001-TB06, SM002-TB01, and SM002-TB02 (Appendix B). The sediments are expected to be fine grained sands from 50 to 55 ft-bgs, then become medium to coarse grained sand with gravel and cobbles from 55 ft- bgs to the total depth of 75 ft-bgs (confirmed by pilot hole). The augers will be advanced to the total depth before the well string is assembled and threaded down through the augers. Heaving sands are expected to invade the central portion of the augers, so a head of water inside the augers may be required to keep the sand from entering too far up the drill string. The supervising geologist may have the drilling crew advance the auger below the targeted depth to compensate for the invading sands.

3.3 RECOVERY WELL CONSTRUCTION

A well string consisting of a five-foot sump of 10-inch ID high carbon steel casing with an OD of 10 ¾ inches will be welded on to the bottom of a 20-foot section of 10-inch ID stainless steel screen. The riser will consist of the same diameter high carbon steel casing welded to the top of the screen. The remaining joints of riser will be threaded. The length of riser is anticipated to be approximately 53 feet, which will leave three feet of casing protruding from the present ground surface of approximately 652 ft-MSL. The final grade of the landfill cover will be approximately 653.5 feet, leaving 1.5 feet protruding from the final ground surface (Figure 2-2).

As previously discussed, this recovery well is expected to be developed naturally, so a filter pack is not anticipated. The formation will be allowed to collapse around the screen as the augers are removed. However, the upper portion of the screened interval (fine grained material) may not collapse as readily, so filter pack sand may be added as the augers are removed from the boring. The HSAs will be slowly removed as the annulus is filled with sand. Filter sand will be also be placed above the screened interval to a point two feet above the first water level contact during drilling. A 3-foot bentonite seal, consisting of pelletized bentonite will be placed above the filter sand and hydrated. The remaining borehole annulus will be filled with bentonite grout using the tremie grouting method.

3.4 RECOVERY WELL DEVELOPMENT

Following the installation of the recovery well, RW-4 will be developed to remove fines and additional water from the screened interval and to ensure proper hydraulic communication with the aquifer. As previously mentioned, pumping of a naturally developed well results in a zone of graded formation materials extending 1 to 2 feet outward from the screen. Beyond that point, the material returns to the original character of the water bearing formation. By creating this graded zone around the screen, development stabilizes the formation and prevents further movement of sediment. After development, groundwater moving towards the screen encounters increasing hydraulic conductivity and porosity. Improving the hydraulic conditions around the well increases the specific capacity and efficiency of the recovery well.

The well development will be conducted by the drilling contractor following the installation of the well. Development will initially consist of introducing a surge block into the recovery well. A surge block can be readily constructed from reinforced rubber pads cut to approximately the same size as the inside diameter of the well screen and bolted to an oversized rod. The rod can then be lowered into the well. Starting at the bottom of the well, the surge block is rapidly raised 3 to 5 feet by a winch on the rig, then allowed to fall to it's original position. This is done to draw the finer formation materials through the screen so they can be pumped out. The surge block is then moved to a higher position within the well, and the process repeated until reaching the top of the screen.

A submersible pump is then introduced to pump the groundwater and sand from the well. The development pump will be placed at different positions within the well screen interval during the procedure. The pump will be moved up and down in one to two feet intervals to surge the well while pumping it. The surging/pumping action will be repeated throughout the length of the screen interval as per MFG SOP #7 (Appendix C).

All groundwater pumped from the recovery well will be routed to the on-site water treatment facility, where it will be treated prior to discharged via a permitted NPDS outfall, similar to the other recovery wells on site. It is anticipated the conveyance pipe used to route the groundwater to the on-site treatment facility, and the electrical hook-up, will be in place prior to drilling the recovery well.

Presently, the treatment system at the Bayer, New Martinsville facility is permitted to treat 6.5 million gallons per day (gpd), but is currently treating between 3 million and 4 million gpd. Using a conservative estimate of 3 million gpd of available capacity, the Bayer treatment facility can handle 2,083 gallons per minute (gpm) of additional flow. The three existing recovery wells currently in place collectively pump approximately 300 gpm to achieve adequate draw-down within the site. Based on these preliminary calculations, there is sufficient treatment capacity to handle any recovery well(s) necessary at the South Landfill.

4.0 GROUNDWATER MONITORING

A site-wide groundwater monitoring program has been established for the Bayer, New Martinsville facility, with quarterly and annual reports submitted to WVDEP, and USEPA. The recovery well, RW-4, will be included in the monitoring program as outline below.

4.1 INTRODUCTION

Bayer started groundwater monitoring in 1985. The quarterly and semi annual monitoring of groundwater has been performed to assess groundwater conditions and to assure the effectiveness of pumping on maintaining hydraulic containment of the plume. Plume configuration maps for the upper and lower portions of the alluvial aquifer were also prepared for each quarter and submitted with the annual reports. These maps show that pumping of the recovery wells has consistently contained the plume on-site.

The wells included in the monitoring network and the sampling frequency are presented on Table 4-1. These monitoring wells provide coverage along the entire perimeter of the plume, as well as internal points that can be used to evaluate recovery well effectiveness through time.

4.2 LANDFILL PERIMETER MONITORING NETWORK

There are several monitoring wells around the perimeter of the South Landfill that can be used for groundwater elevations. Some of these monitoring wells are in clusters that are completed to perched, shallow, and deep aquifer zones. All available monitoring wells are depicted on Figure 2-1. The monitoring wells highlighted in Figure 2-1 will be extended, as required, to be above grade after final grading, as outlined in a separate document, <u>The Remedial Action Work Plan for SWMU Group A, South Landfill February 2004.</u> The estimated extension lengths and monitoring well specs are listed in Table 4-2. These monitoring wells will also be resurveyed so that water level elevation data gathering is not interrupted.

4.2.1 Location of Wells

Bayer collects groundwater elevation data on a quarterly basis and publishes the results in quarterly groundwater reports to WVDEP and an annual groundwater report every year to WVDEP and USEPA. Bayer already has a monitoring program in place, collecting groundwater samples from monitoring wells LF-1S, LF-7S along the southern perimeter, and from monitoring wells FP-19, MW-11, MW-12, MW-14 and MW-15 to the south of the South Landfill. In addition, samples are collected from LF-4S and LF-4D to the north of the landfill, and FP-17 to the northeast.

4.2.2 Depth of Wells

The depth of the groundwater monitoring wells vary from 15 feet below ground surface (ft-bgs) to 64 ft-bgs depending on the alluvial aquifer being monitored. Table 4-2 lists the total depth of each monitoring well, the current elevations, and the expected elevations after final grading. The total depth below ground surface will change, once the final grading of the landfill cover is complete, however, the elevation of the total depth will remain the same, for each monitoring well on Figure 2-2. These include all the monitoring wells in Table 4-2. The total depth of the recovery well is anticipated to be approximately 75 ft-bgs.

4.2.3 Construction of Wells

All existing monitoring wells are constructed of 2-inch ID flush threaded, schedule 40 PVC, with at least 10 feet of 0.010-inch slotted, flush threaded, PVC screen on the bottom. Table 4-2 lists the ground and PVC riser elevations, screen lengths, as well as the total depths of the monitoring wells used around the South Landfill.

As previously mentioned, it is anticipated that the recovery well, RW-4, will be constructed of 10-inch ID stainless steel screen welded to threaded, 10-inch steel casing. The discharge lines for the recovery well are anticipated to be 6-inch threaded steel pipe.

4.3 SAMPLING FREQUENCY

The sampling frequency for the perimeter monitoring wells will remain on a semi-annual basis as presented in Table 4-1. The new recovery well, RW-4 will be added to the schedule to be samples during the first and third quarters along with the existing recovery wells. However, monitoring wells FP-17, FP-19, MW-11D, MW12D, MW14, and MW-15 will be sampled quarterly, so that the monitoring schedule remains the same. Groundwater elevation measurements will continue to be recorded on a quarterly basis.

4.4 SAMPLING PARAMETERS

Groundwater sampling parameters are listed in Table 4-3. Conventional water quality data consists of the field parameters conductivity, pH, and temperature. Sulfate, total dissolved solids, and total organic carbon are derived in the laboratory. Metals include antimony, cadmium, chromium, lead, and nickel. The list of semi-volatiles and volatiles are list on Table 4-3. Monitoring wells FP-17, FP-19, MW11D, and MW-12D are analyzed for dioxins on an annual basis.

4.5 REPORTING

The Bayer, New Martinsville Plant reports selected analytical results to the WVDEP on a quarterly basis, and summarizes the information in an annual groundwater report to the USEPA. The annual report also includes groundwater elevation maps, and additional information regarding samples collected from the neighboring Grandview-Doolin water supply company, and two residences.

5.0 PUMPING TEST

A pumping test following ASTM standard 4050-91 (Appendix D) will be performed on the recovery well, using the monitoring wells surrounding the South Landfill as sentry wells to make sure that the water levels within the landfill are being lowered according to the model. A map showing the locations of the proposed recovery well and the sentry wells is provided as Figure 2-2. The pumping test will occur after Bayer technicians have hooked up the discharge lines to carry the groundwater to the treatment facility. Every effort will be made to maintain the rate of groundwater extraction throughout the time of the recovery well pumping test. PPG personnel will be notified of the pumping test schedule.

5.1 PUMP TEST PREPARATION

Upon completion of well installation and development activities, set-up for the aquifer test will commence. It is assumed that discharge water from the pumping test will be piped to the on-site treatment facility. This task will consist of the following activities:

Installation and wiring of submersible pump;

Piping of discharge line to conveyance lines leading to the on-site treatment facility;

Installation of flow meter and adjustment valve into discharge line;

Installation of pressure transducers into monitoring points and hook-up of data logger to record water level changes.

It is important to note that the discharge water from the well must exceed 30 lbs. pressure to prevent significant backpressure on the discharge line as pumping progresses and to deliver water to the on-site treatment facility. Set-up for the aquifer test will take approximately two days to complete.

Figure 2-2 shows the layout of the existing monitoring well locations and the proposed layout of pressure transducers for water level monitoring. Eight monitoring well locations will be equipped with pressure transducers (Well Troll) with internal memories to store the required amount of information. Eight monitoring wells were selected from Table 4-2 to be equipped with pressure transducers (Well Trolls). The eight wells located around the perimeter include LF-1D, LF-2D, LF-3D, LF-4D, LF-7D, OTW-4, FP-17, and FP-19.

Based upon the results of well development activities and preliminary flow testing at the recovery well location, an appropriate submersible pump will be selected to perform the aquifer-pumping test. The submersible pump and check valve will be installed into RW-4 with HDPE discharge piping being routed to the conveyance lines leading to the on-site treatment facility. The selection of the pump will take into account the head required to pump groundwater to the treatment facility. An inline flow meter will also be installed to facilitate flow rate measurement during pumping test activities.

5.1.1 Background Water Level Monitoring

Prior to initiating the aquifer-pumping test, groundwater levels in the monitoring well network will be monitored to evaluate any flow trends or potential influences that may affect the pumping test. If trends are apparent, the trend data will be evaluated to determine potential influences on data collected during the performance of the constant rate test. Bayer will maintain constant pumping rates on the current recovery wells so as not to influence the constant rate test. Another outside influence to be considered are the production well at the neighboring PPG facility to the north. PPG personnel will be notified of the pumping test schedule.

Normally, while evaluating water level fluctuations in the vicinity of the pumping test, barometric pressure would also be monitored to determine potential influences in water levels. However, the Well Troll pressure transducers are equipped with a vented cable, canceling the effect of barometric pressure fluctuations.

5.1.2 Measurement Duration and Frequency

Immediately before pumping is to begin, static water levels in all test and monitoring wells should be recorded manually. Manual groundwater elevation data will be collected from the eight monitoring wells equipped by pressure transducers periodically throughout the pumping test.

Recovery measurements are made in the same manner and frequency as the drawdown measurements. All manual measurements of water levels and times will be recorded on pre-printed forms attached to MFG SOP #7 in Appendix C.

5.2 STEP DRAWDOWN TEST

A step drawdown test will be performed to determine the optimum pumping rate for the constant rate test. The step test will be performed over a one-day period. The test will be initiated by pumping a constant flow rate (Q) as determined by the MFG field geologist for a period of one to two hours. Water levels will be evaluated during this initial 1-2 hour period until the drawdown in the pumping well stabilizes. The well will then be pumped at a higher pumping rate (typically double the initial rate) and the drawdown for this rate, or step, will be recorded as for the first step. This procedure will continue until a minimum of four steps of successively higher pumping rates are completed. The step test will permit the calculation of specific capacity of the recovery well at various pumping rates. This information will be used to select optimum discharge rates during the pumping test.

5.3 72-HOUR CONSTANT RATE PUMPING TEST

After completion of the step drawdown test, determination of an optimum pumping rate and after water levels in monitoring wells have returned to static conditions, a constant rate test will begin. Prior to the start of the test, one round of manual water level measurements will be made in all the groundwater monitoring points for quality control. The purpose of the constant rate test is to determine the transmissivity (T) and the storage coefficient (S) for the aquifer.

5.3.1 Pump and Discharge Piping

The pump to be utilized during the step drawdown test and constant rate pumping test is anticipated to be a 3 phase, 15 - 20 horsepower, submersible pump. The anticipated pumping flow rates range from 150 to 300 gallons per minute (gpm). A more accurate determination of pump requirements will be made during the well installation phase after initial well development of the pumping well. In order to obtain good data during the period of recovery, at the end of pumping, it is necessary to have a check valve installed at the base of the pump column piping in the discharging well. This will prevent the back flow of water from the riser pipe into the well when the pumping portion of the test is terminated and the recovery begins. Any back flow into the well will interfere or mask the water level recovery of the aquifer and this would make any aquifer analysis based on recovery data useless or at best questionable. The pump selected will be evaluated based on the total head required to pump water from the bottom of the well to the on-site treatment facility.

5.3.2 Discharge Monitoring Equipment

Discharge from the pumping well will be monitored during the aquifer test using an in-line totalizing flow meter. Flow measurements will be monitored frequently during the aquifer test to assure that minimal variation in the pumping rate occurs. If variations are noted, adjustments will be made and documented to maintain a steady flow rate. The variation of discharge rate has a large effect on permeability estimates calculated using data collected during a test. The discharge rate should not vary more than 10% during the duration of the test.

5.4 WATER LEVEL MONITORING EQUIPMENT

In-Situ Well Troll pressure transducers will be utilized to monitor water levels in the pumping well and the surrounding monitoring wells in the area of concern. The Well Trolls record water levels measured by pressure sensitive transducers placed below the water surface at each monitoring well location. Since the transducers are vented to the atmosphere by a capillary tube, water level measurements recorded by this instrument are automatically corrected for changes in barometric pressure.

5.5 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

Laboratory measurements of transducer response and instrument drift are performed on all transducers prior to mobilization. Transducer drift test results are useful in evaluating the degree of precision associated with water levels measured by the transducers.

The criteria for rejection of a pressure transducer for use in the aquifer test are based on drift reproducibility. If the transducer signal varies more than 0.05 foot when placed in a constant temperature water vessel over a twelve-hour period, the transducer is not used. Additionally, if the transducer fails to reproduce a water level reading within 0.05 foot when tested in the constant temperature water vessel, the transducer is not used and returned to the manufacturer for repair or replacement.

Introducing transducers into monitoring wells changes the water levels in those wells. Testing cannot begin until water levels have re-stabilized. Also, time is necessary for the transducers to equilibrate with the ambient water temperature. Aquifer testing, therefore, begins at least 3 hours following the set-up of the transducers.

Finally as part of the quality control / quality assurance measures, the water levels recorded by the Well Trolls will be compared to the manual measurements obtained throughout the aquifer test.

5.6 CRITERIA FOR SUCCESS

There are several issues relating to the success of an aquifer pumping test that involve the determination of aquifer properties such as hydraulic conductivity. However, the best measure of success will be the draw-down realized in the recovery well (RW-4) and the surrounding sentry wells while pumping RW-4 at the expected production rate of 150 gpm. This information will demonstrate that the recovery well is effectively capturing the groundwater and associated constituents of concern from beneath the landfill, augmenting the groundwater recovering system that is already in place. The draw-down within RW-4 should reach 3 to 4 feet below static levels, and the sentry wells should reach a draw-down between 1.2 and 1.5 feet below static levels as presented in Figure 2-1 and outlined in the table below:

Monitoring Well	Total Depth (feet)	Elevaltion Ground	Elevaltion (1)TOC_{PVC}	Screened Interval From	Screened Interval To	Screen Length (feet)	Transducer Installation	Expected Drawdown (feet)
		(ft-MSL)(2)		(ft-bgs)(3)				
LF-1D	64	636.12	637.54	39	64	25	X	**1.2**
LF-2D	64	634.89	636.62	39	64	25	X	**1.5**
LF-3D	68	637.73	639.65	43	68	25	X	**1.4**
LF-4D	60	633.64	635.51	35	60	25	X	**1.3**
LF-5D	59	632.52	634.1	34	59	25	X	**1.3**
LF-6D	58	630.74	632.61	33	58	25	X	**1.3**
LF-7D	60	631.45	632.89	35	60	25	X	**1.2**
OTW-4	N/A(4)	633.26	635.46	N/A	N/A	N/A	X	**1.3**

Notes (1) TOC_{PVC}=Top of Casing (PVC)
(2) ft-MSL=feet above mean sea level
(3) ft-bgs=feet below ground surface
(4) N/S=Not Available

The expected draw-down reflects the predicted outcome from the steady state groundwater model at the site. Bayer wants to be sure that the steady state groundwater model (developed for the site) is correct in predicting how the aquifer will perform. This is important when considering future corrective measures for various SWMU groups throughout the New Martinsville facility.

criteria used in judging the success of the aquifer test for recovery well RW-4 is actually in how the empirical data compares to the predicted outcome of the test.

A further measure of success for both the aquifer test and the model will be the correlation of empirical data and predicted outcome. The groundwater elevations in the sentry wells should come within 0.5 feet of the predicted elevation outlined above. Hydraulic conductivity is also a major component to groundwater flow. The model predicts a range of hydraulic conductivity to be between 600 and 1,000 feet per day. Meeting these criteria would demonstrate that the steady state groundwater model developed for the Bayer, New Martinsville facility accurately mimics reality by matching the empirical data collected.